Methods of Tests of Axles for Trucks and Buses

FOREWORD

This Test Standard was proposed by The Automotive Research Association of India as guideline for testing of heavy commercial vehicles (HCV) axles.

Recently there have been changes in axle load norms by government of India in which the axle loads have been increased by around 10-15 percent. There is no current test standard for testing of HCV axles, the outcomes mentioned in this standard are derived from experiments conducted on actual vehicles and data and results derived thereof.

METHODS OF TESTS OF AXLES FOR TRUCKS AND BUSES

1 SCOPE

This standard specifies four laboratory test methods for evaluating fatigue life characteristics of axles used for Commercial Vehicles and Heavy Commercial Vehicles above 16 Ton Gross Vehicle Weight of haulage application.

The Test Methods are:

a. Vertical Beaming Test
b. Longitudinal Braking Loading test
c. Longitudinal Spindle Loading Test
d. Lateral Spindle Bending Test

2 REFERENCE

Currently there are no test standards or generic methods available in public domain for fatigue testing of commercial vehicle axles. Comprehensive experiments and load measurements were carried out on test vehicles to arrive at a generic test methodology and test cycles. Current industry practices were also studied in depth before the experiments were conducted and the findings were discussed with industry members before preparation of this standard.

3 TERMS AND DEFINITIONS

3.1 Front Axle

Front Axle is the non-driven steerable axle on the front side of the vehicle with a 7Ton load capacity limit. Some heavy commercial vehicles may have more than 1 front axle.

3.2 Rear Axle

Rear Axle is the powered or non-powered axle located at the rear side of the vehicle which is always engaged and has no mechanism to lift the axle during running of vehicle

3.3 Lift Axle

Lift Axle means an axle which can be raised / lowered by the axle lift device either by raising the wheels clear off the ground / lowering them to the ground, or without raising the wheels off the ground, (e.g., in the case of air suspension systems, or other systems)

3.4 'G'

G refers to the static axle load in N acting on each side of the axle viz. LH and RH.

e.g.) For an 11 Ton Axle, 1G corresponds to (1*11,000*9.81)/2 = 53955N on LH and RH wheel each

3.5 Axle static Payload: Axle rated load in tons specified by the axle manufacturer.

3.6 Test load: The peak fatigue test load on each axle corner in sinusoidal loading cycles.

3.7 Test cycles: Number of sinusoidal cycles, the component is to be tested for.

4 GENERAL

Only fully processed new axles which are representative of axles to be used in intended vehicles shall be used for the test. In case of Longitudinal and Lateral Loading Tests, test is to be carried out for both LH and RH side of the axle.

It is recommended to carry out each test on a new axle sample. The test load and test cycles for each test type are provided in a tabular format for the applicable axle load for the test engineer to select from.

5 TESTS

5.1 Equipment

The fatigue tests require servo hydraulic actuators connected to a high-pressure hydraulic system capable of providing the intended loads within an error of ± 2%, (recommended 250kN Actuators capable at running up-to 5Hz Frequency). Additional Fixturing connected to a strong floor is required for providing sufficient reactions to the axle as well as the actuators.

5.2 Vertical Beaming Tests of Rear Axles

5.2.1 Preparation

Axle is to be constrained using a mechanical setup such that load can be applied in the vertical direction on spring seats while providing a vertical reaction at spindle points (Wheel hub point). Actuators shall be connected to the spring seats via appropriate mechanical arrangement. The vertical reaction should have a free pivot degree of freedom at the spindle point along the axis parallel to the vehicle longitudinal direction. A representative test setup is depicted in Figure 1

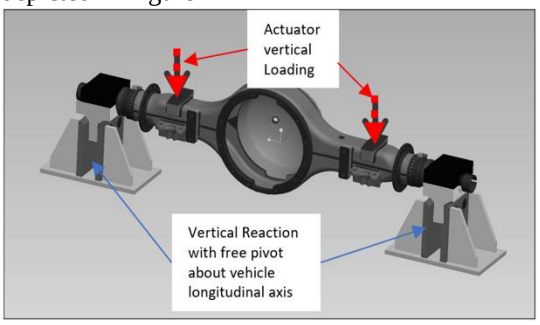

Figure 1 : Test Setup for Vertical Beaming Test

5.2.2 Procedure

A cyclic load of 0 to 2G (Test load) which is twice the static operating payload of the axle is to be applied on spring seats. The loading signal shall be sinusoidal up-to a rate of 2Hz or as specified by manufacturer based on the suspension dominant frequencies. Test Cycles and applicable test load for different axle static operating/rated loads are given in Table 1. The test engineer shall select the appropriate test load and test cycles based on the rated axle static payload of the axle under test.

e.g. For vertical beaming fatigue testing of an 11 Ton Rear Axle, test load on LH and RH side will be 107.9 kN and minimum required test cycles without failure shall be 5,76,000 cycles

Axle Static Payload (tons)	2G Test Load on each side (kN)	Test Cycles
9.5	93.2	852000
10	98.1	743000
10.5	103.0	652000
11	107.9	576000
11.5	112.8	512000
12	117.7	457000
12.5	122.6	409000
13	127.5	369000
13.5	132.4	333000
14	137.3	302000
14.5	142.2	275000

Table 1 : Test Specifications for Vertical Beaming Test of Rear Axles

5.3 Longitudinal Braking Loading Test of Rear Axles

5.3.1 Preparation

Axle is to be constrained using a mechanical setup such that a load can be applied in the longitudinal direction of braking on a mechanical arm connected to the spindle at a distance equal to the dynamic tyre radius of the wheel from the spindle centre. The servo-hydraulic actuator should be connected to the end of this arm. The axle should be constrained in all degrees of freedom at both the spring seat mounting points. A representative test setup is depicted in Figure 2.

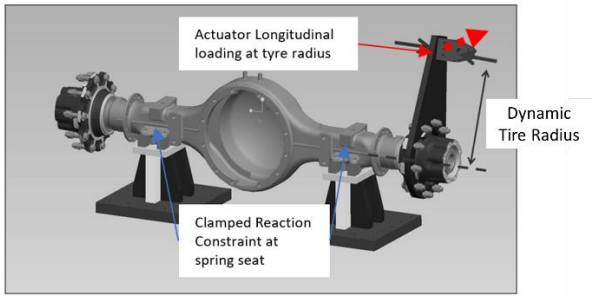

Figure 2: Test Setup for Longitudinal Braking Test

5.3.2 Procedure

A cyclic load of 0 to 0.5G (Test load) which is equal to 0.5 times the static operating payload of the axle is to be applied towards the axle in the longitudinal direction on a moment arm representing the dynamic tyre radius. The loading signal shall be sinusoidal up-to a rate of 1Hz or as specified by manufacturer. Test Cycles and applicable test load for different axle static operating/rated loads are given in Table 2. The test engineer shall select the appropriate test load and test cycles based on the rated axle static payload of the axle under test.

Axle Static Payload (tons)	0.5G Test Load on Each Side (kN)	Test cycles
9.5	23.3	53500
10	24.5	47500
10.5	25.8	42000
11	27.0	36500
11.5	28.2	31500
12	29.4	26500
12.5	30.7	22000
13	31.9	17000
13.5	33.1	13000
14	34.3	8500
14.5	35.6	4500

Table 2: Test Specifications for Longitudinal Braking Loading Test of Rear Axles

5.4 Longitudinal Spindle Loading Test of Rear Axles

5.4.1 Preparation

Axle is to be constrained using a mechanical setup such that a load can be applied in the longitudinal direction at the spindle centre. The servo-hydraulic actuator should be connected to the spindle center in the longitudinal direction via suitable mechanical arrangement. The axle should be constrained in all degrees of freedom at both the spring seat mounting points. A representative test setup is depicted in Figure 3

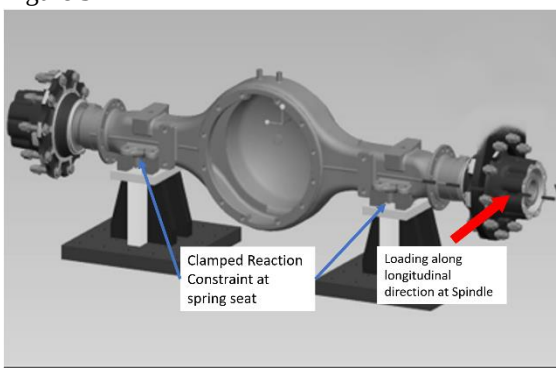

Figure 3: Test Setup for Longitudinal Spindle Loading Test

5.4.2 Procedure

A cyclic load of 0 to ±0.5G (1G Range) which is equal to 0.5 times the static operating payload of the axle is to be applied towards the axle in the longitudinal direction in a To and Fro manner at the spindle centre. Positive load corresponds to the load applied away from the actuator on to the spindle centre and negative load corresponds to the load applied on the spindle centre towards the actuator. The loading signal shall be sinusoidal up-to a rate of 1Hz or as specified by manufacturer. Test Cycles and applicable test load for different axle static operating/rated loads are given in Table 3. The test engineer shall select the appropriate test load and test cycles based on the rated axle static payload of the axle under test.

Axle Static Payload (tons)	0.5G Test Load on each side (kN)	Test Cycles
9.5	±23.3	199000
10	±24.5	173000
10.5	±25.8	152000
11	±27.0	134000
11.5	±28.2	118500
12	±29.4	105500
12.5	±30.7	94500
13	±31.9	85000
13.5	±33.1	77000
14	±34.3	69500
14.5	±35.6	63500

Table 3: Test Specifications for Longitudinal Spindle Loading Test of Rear Axles

5.5 Lateral Spindle Bending Test of Rear Axles

5.5.1 Preparation

Axle is to be constrained using a mechanical setup such that a load can be applied in the lateral direction (inwards and outwards) on a mechanical arm connected to the spindle at a distance equal to the dynamic tyre radius of the wheel from the spindle centre. The servo-hydraulic actuator should be connected to the end of this arm in the lateral direction. The axle should be constrained in all degrees of freedom at both the spring seat mounting points. A representative test setup is depicted in Figure 4

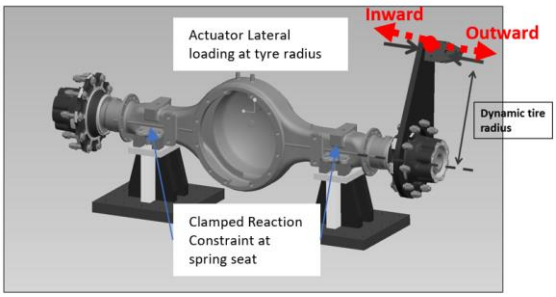

Figure 4: Test Setup for Lateral Spindle Bending Test

5.5.2 Procedure

A cyclic load of 1G Range (-0.6G inward to +0.4G outward) where 1G is equal to the static operating payload of the axle is to be applied on the axle in the lateral direction on a moment arm representing the dynamic tyre radius. The loading signal shall be sinusoidal up-to a rate of 1Hz or as specified by manufacturer. Test Cycles and applicable test load for different axle static operating/rated loads are given in Table 4. The test engineer shall select the appropriate test load and test cycles based on the rated axle static payload of the axle under test.

Axle Static Payload (tons)	Test Load on Each Side		Test Cycles
	Inward From (-0.6G) (kN)	Outward To (+0.4G) (kN)	
9.5	-28.0	+18.6	128500
10	-29.4	+19.6	106500
10.5	-30.9	+20.6	89000
11	-32.4	+21.6	75000
11.5	-33.8	+22.6	63500
12	-35.3	+23.5	54500
12.5	-36.8	+24.5	47000
13	-38.3	+25.5	40500
13.5	-39.7	+26.5	35500
14	-41.2	+27.5	31000

Table 4: Test Specifications for Lateral Spindle Bending Test of Rear Axles

5.6 Vertical Beaming Tests of Front Axles

5.6.1 Preparation

Axle is to be constrained using a mechanical setup such that load can be applied in the vertical direction on spring seats while providing a vertical reaction at spindle points. Actuators shall be connected to the spring seats via appropriate mechanical arrangement. The vertical reaction should have a free pivot degree of freedom at the spindle point along the axis parallel to the vehicle longitudinal direction. The test setup is similar to the setup depicted in Figure 1

5.6.2 Procedure

A cyclic load of 0 to 2G (Test load) which is twice the static operating payload of the axle is to be applied on spring seats. The loading signal shall be sinusoidal up-to a rate of 2Hz or as specified by manufacturer based on the suspension dominant frequencies. Test Cycles and applicable test load for different axle static operating/rated loads are given in Table 5. The test engineer shall select the appropriate test load and test cycles based on the rated axle static payload of the axle under test.

Axle Static Payload (tons)	2G Test Load on Each Side (kN)	Test Cycles
6	58.9	400000
7	68.7	218000
8	78.5	128500

Table 5: Test Specifications for Vertical Beaming Test of Front Axles

5.7 Longitudinal Braking Loading Test of Front Axles

5.7.1 Preparation

Axle is to be constrained using a mechanical setup such that a load can be applied in the longitudinal direction on a mechanical arm connected to the spindle at a distance equal to the dynamic tyre radius of the wheel from the spindle centre. The servo-hydraulic actuator should be connected to the end of this arm. The axle should be constrained in all degrees of freedom at both the spring seat mounting points. The Test setup is similar to as depicted in Figure 2.

5.7.2 Procedure

A cyclic load of 0 to 0.5G which is equal to 0.5 times the static operating payload of the axle is to be applied towards the axle in the longitudinal direction on a moment arm representing the dynamic tyre radius. The loading signal shall be sinusoidal up-to a rate of 1Hz or as specified by manufacturer. Test is to be carried out for 90,000 cycles at 0.5G load for a 7 Ton axle.

5.8 Longitudinal Spindle Loading Test of Front Axles

5.8.1 Preparation

Axle is to be constrained using a mechanical setup such that a load can be applied in the longitudinal direction at the spindle centre. The servo-hydraulic actuator should be connected to the spindle centre in the longitudinal direction via suitable mechanical arrangement. The axle should be constrained in all degrees of freedom at both the spring seat mounting points. The test setup is similar to as depicted in Figure 3

5.8.2 Procedure

A cyclic load of +0.6G (Braking Direction) to -0.4G (Opposite to Braking Direction) (1G Range) which is equal to 0.6 and 0.4 times the static operating payload respectively of the axle is to be applied towards the axle in the longitudinal direction at the spindle centre. Positive load corresponds to the load applied away from the actuator on to the spindle centre and negative load corresponds to the load applied on the spindle centre towards the actuator. The loading signal shall be sinusoidal up-to a rate of 1Hz or as specified by manufacturer. Test Cycles and applicable test load for different axle static operating/rated loads are given in Table 6. The test engineer shall select the appropriate test load and test cycles based on the rated axle static payload of the axle under test.

Axle Static Payload (tons)	Test Load on Each Side		Test Cycles
	From (Opposite to braking Direction -0.4G) (kN)	To (Towards braking Direction +0.6G) (kN)	
6	-11.8	17.7	96500
7	-13.7	20.6	63500
8	-15.7	23.5	44000

Table 6: Test Specifications for Longitudinal Spindle Loading Test of Front Axles

5.9 Lateral Spindle Bending Test of Front Axles

5.9.1 Preparation

Axle is to be constrained using a mechanical setup such that a load can be applied in the lateral direction (inwards and outwards) on a mechanical arm connected to the spindle at a distance equal to the dynamic tyre radius of the wheel from the spindle centre. The servo-hydraulic actuator should be connected to the end of this arm in the lateral direction. The axle should be constrained in all degrees of freedom at both the spring seat mounting points. Test setup is similar to as depicted in Figure 4.

5.9.2 Procedure

A cyclic load of 0.5G Range (-0.3G inward to +0.2G outward) where 1G is equal to the static operating payload of the axle is to be applied on the axle in the lateral direction on a moment arm representing the dynamic tyre radius. The loading signal shall be sinusoidal up-to a rate of 1Hz or as specified by manufacturer. Test Cycles and applicable test load for different axle static operating/rated loads are given in Table 7 . The test engineer shall select the

appropriate test load and test cycles based on the rated axle static payload of the axle under test.

Axle Static Payload (tons)	Test Load on Each Side		Test Cycles
	Inward (From -0.3G) (kN)	Outward (To -0.2G) (kN)	
6	-8.83	5.89	285500
7	-10.30	6.87	126500
8	-11.77	7.85	62500

Table 7: Test Specifications for Lateral Spindle Bending Test of Front Axles

5.10 Testing of Lift Axles

Lift Axles towards the front shall be tested with cycles as prescribed for Front Axles

6 ACCEPTANCE CRITERIA

The Axle shall be inspected with a non-destructive test inspection such as a die penetration test to verify that no visible cracks should appear on the test axles after completion of the required fatigue test cycles. Minimum 3 samples are recommended to be tested. For Longitudinal and lateral loading tests, both LH and RH sides are to be tested separately.